Scanned by Zinith Barbee | Date 5/21/09 | Doc ID # 7358

CIVIL/SANITARY/ENVIRONMENTAL ENGINEERS
SOLID WASTE MANAGEMENT
Municipal Services Engineering Company, P.A.
SITE PLANNING/SUBDIVISIONS
SUBSURFACE UTILITY ENGINEERING (SUE)

Mr. Zinith Barbee, Project Manager
Solid Waste Section
Division of Waste Management
North Carolina Department of Environment and Natural Resources
401 Oberlin Road, Suite 150
Raleigh, NC 27605

May 13, 2009

RECEIVED
MAY 14 2009
SOLID WASTE SECTION

Re: **Response to Document ID 7138, Dated April 13, 2009**
Revised Corrective Action Plan
Greene County Landfill
Construction and Demolition Landfill Permit 40-02

Dear Mr. Barbee:

Municipal Engineering Services Company, PA (MESCO) appreciates the opportunity to respond to comments and requests presented in your April 13, 2009 letter (Document ID 7138) initiated after the Solid Waste Section's (SWS's) review of our *Revised Corrective Action Plan* submitted on February 25, 2009. We have attempted to respond to your comments in the order presented in the referenced letter.

With regards to Zero-Valent Iron (ZVI) remediation technology recommended in our revised Corrective Action Plan (CAP) and referenced in your initial and second paragraphs, a review of the data suggests that ZVI technology should not be required at this site. Instead, we have revised our CAP to recommend Monitored Natural Attenuation (MNA) as the sole remedy instead of "pairing" with another remedy (i.e., ZVI, etc.) as indicated in our submittal. It is our position that MNA can be effective as a sole remedy based on reported contamination levels and estimated groundwater flow direction and velocities, and that none of the eleven restricting conditions listed in the Corrective Measures guidance document located at your webpage (http://www.wastenotnc.org/swhome/EnvMonitoring/ExamplesGWCorrectiveMeasures%20rev4-08.pdf) have been met or detected at this site. However, as presented in the *Assessment of Corrective Measures (ACM)* dated August 30, 2007, we have recommended implementing phytoremediation technology as our primary contingency plan followed by injection of "alternate substrates" (i.e., ORC, HRC, etc.) if necessary. To facilitate approval of the CAP, we included recommendations regarding tree selection and spacing, and an estimated cost to implement the remedy.

At the bottom of page one of your letter, you indicated that revisions to selected sections of our submittal were "… required regardless of what remediation technology is selected." Below we have presented our perspective on the information presented in the referenced sections of the CAP and/or indicated how and where in the CAP we have addressed your concerns. As indicated in your letter (and as above) "…the number and titles correspond to the sections in the CAP."

Comment: 1.2 Correct description of groundwater flow directions and provide more information about groundwater flow near the two ditches that appear in and near the contamination plume associated with MW-4.

Response: *As indicated correctly in your letter, groundwater appears to be flowing easterly beneath the site and we have corrected our CAP accordingly. With regards to groundwater flow near MW-4, it is our opinion that the drainage ditch located north of the well has only minimally affected groundwater flow in the immediate area. Under normal conditions, the static water level in the ditch ranges from approximately 8 to 10 feet below the ground surface (bgs). The static water level in the nearby monitor wells ranges from approximately 10 feet bgs in compliance wells MW-7 and MW-8 to approximately 17 feet bgs in downgradient wells MW-4 and MW-5. While the ditch can serve as a seasonal discharge point to draw, drain and/or lower localized groundwater from beneath the borrow pit, it is our opinion that the implied northeasterly pull on the plume has been insignificant.*

Comment: **1.3 Match the constituents targeted by the CAP with the constituents of concern (COCs) listed in the ACM.**

- **Include lead and iron as additional COCs.**

Response: *The organic compounds reported as COCs in the ACM have been added to the revised CAP. However MESCO did not characterize metals as COCs in the ACM or CAP. As presented in Section 2.1.1 (Inorganic Constituents) of the ACM, " The presence of metals occurring in the background samples, surface water samples, soil samples, and NURE sediment samples indicate that Antimony, Barium, Beryllium, Cadmium, Chromium, Lead, Manganese, Nickel, Thallium, Vanadium and Zinc are falsely reported, or naturally occurring and don't represent contamination associated with the landfill...The above results indicate that inorganics are not constituents of concern." Additionally, because the C&D Landfill was constructed on top of a closed, unlined municipal solid waste landfill (MSWLF), groundwater is monitored in accordance with "the 1600 Rules" (which does not include analysis for iron) and not "the 500 Rules" (which includes iron). Based on this data, MESCO did not include metals as COCs in the ACM, revised CAP, nor in this revision.*

- **Explain how the contamination plume has been determined.**

Response: *As reported in the ACM, the contaminant plume was determined from plume models created by MODFLOW (with transport package $MT3D^{96}$) used to simulate a release. Modeling parameters assumed leakage occurred prior to installation of the cap systems. As with the development of the MODFLOW model, $MT3D^{96}$ transport was calibrated with a trial and adjustment procedure. The retardation coefficient and dispersion factors were calibrated to time periods 2006 and 2007. In an attempt to incorporate historical data, we used 1990 as a baseline, and target step periods of 5 years (1995), 16 years (2006), 17 years (2007), 25 years (2015), 35 years (2025), and 50 years (2040) were simulated in the model. The plume contours were manually transposed onto the plates and discussed in the text.*

Comment: **1.4 Expand the table to include lead, iron, and all of the COCs listed in the ACM.**

Response: *See our response presented in Section 1.3.*

- **Revise the "site conceptual model" to show the groundwater flow depicted on potentiometric maps submitted with the March 2008 Sampling Report.**

Response: *We have not revised the site conceptual model as requested because it is our opinion that groundwater typically flows in the direction provided in the CAP. Occasionally, there might be minor fluctuations in groundwater velocity or direction. However, we feel we have presented the typical general groundwater flow direction across the site.*

Comment: **2.1 Expand the list to include lead, iron, and all COCs listed in the ACM.**

Response: *See our response presented in Section 1.3.*

Comment: **2.5.2 Match the reported history of constituents exceeding groundwater standards with the history reported in the ACM.**

Response: *The constituents exceeding groundwater standards that were reported in the ACM have been added to the revised CAP.*

Comment: **4.1 Clarify whether it is MW-1 or MW-1R that will be utilized as the background well.**

Response: *As indicated in Section 1.1.2 Sampling History on Page 1 of the Assessment of Corrective Measures Report, we indicated "...in October 1994, MW-1R was installed adjacent to MW-1 because the integrity of MW-1 was in question." As such, MW-1R will be used as the background well. We have corrected Section 4.1 to reflect that change.*

Comment: **6.2 Include more data about the existing "passive horizontal gas venting system".**

Response: *MESCO presented additional details about the existing "passive horizontal gas venting system" in Section 2.3 of the revised CAP. Instead of repeating that information in Section 6.2, we referred the reader to Section 2.3.*

Comment: **8.0 Correct the statement to reflect that financial assurance for corrective action had not been submitted.**

Response: *MESCO revised the referenced section to state, "...Semi-annual costs are/were estimated in the post-closure financial assurance. However, even though estimated costs to perform corrective action and an initial contingency plan (phytoremediation) are relatively minor, to date, financial assurance for corrective action has not been submitted."*

Plates **Show location of the relevant point of compliance.**

Response: *MESCO has modified the Plates to reflect the relevant points of compliance.*

Comment **Include MW-5, MW-6, and MW-7 in assessment monitoring in the Groundwater and Surface Water Sampling and Analysis Plan.**

Response: *MESCO removed the Detection Monitoring section of the Groundwater and Surface Water Sampling Analysis Plan presented in Appendix B and added monitor wells MW-5, MW-6, MW-7, and MW-8 to the Assessment Monitoring section.*

We appreciate the opportunity to respond to your comments and questions and hope that our responses have been acceptable. We have attached a DRAFT copy of our revised CAP (text) for your review and approval. If you have additional comments or questions, please contact us at 919.772.5393, at spatrick@mesco.com or mbrown@mesco.com.

Sincerely
Municipal Engineering Services Company, PA

Sean Patrick, P.G.
Project Geologist

Mark Brown, LG, PG
Senior Geologist

smb/SMB

H:\C&D CAP\Greene\Response to Zinith ltr dated 041309.doc

RECEIVED
MAY 14 2009
SOLID WASTE

NCDENR

North Carolina Department of Environment and Natural Resources

Dexter R. Matthews, Director

Division of Waste Management

Beverly Eaves Perdue, Governor
Dee Freeman, Secretary

April 13, 2009

Mr. David Jones
Public Works Director
Post Office Box 543
Snow Hill, North Carolina 28580

RECEIVED
APR 14 2009

Subject: Revised Corrective Action Plan
Greene County Landfill
Construction and Demolition Landfill Permit 40-02
Doc ID 7138

Dear Mr. Jones:

The Solid Waste Section (SWS) reviewed the revised Corrective Action Plan (CAP) for the Greene County Landfill, received February 25, 2009. The CAP had been prepared and submitted by Municipal Engineering Services Company, P.A. (MESCO). Zero-Valent Iron (ZVI) remediation technology is proposed as a corrective measure paired with Monitoring Natural Attenuation. However, ZVI had not been previously proposed. In November 2007, SWS approved the report, *Assessment of Corrective Measures prepared for Greene County Landfill*, dated August 2007, in which a variety of corrective measures are described. On February 29, 2008, Greene County held a public meeting in which those assessed corrective measures had been discussed with affected and interested parties. ZVI had not been included among corrective measures discussed in the ACM or presented to the public. Therefore, its inclusion in the CAP cannot be approved at this time.

The following steps are required for AZI to be reviewed in a revised CAP. One, amend the ACM with a report describing AZI. The amendment should meet requirements specified in 15A NCAC 13B .1635. Two, pursuant to 15A NCAC 13B .1635(d), hold an additional public meeting with "interested and affected parties". Three, notify the SWS that ZVI is the remedy selected by the county pursuant to 15A NCAC 13B .1636. Four, following the SWS's approval of the selected remedy, submit the application, "North Carolina Solid Waste Groundwater Corrective Action Permit Modification Application". The application is accessible through the SWS website: http://www.wastenotnc.org/swhome/EnvMonitoring/NCSWGWCAPermitmod_20080215.pdf. Five, submit a revised CAP. The approved corrective measure shall then be implemented in accordance with 15A NCAC 13B .1637.

Although the current revised CAP is not accepted, listed below are revisions that are required regardless of what remediation technology is selected. Please note that comment on ZVI is excluded. The numbers and titles correspond to the sections in the CAP.

1.2 Correct description of groundwater flow directions. Flow is described as flowing westerly when maps show it flowing east and easterly. Also, provide more information about groundwater flow near the two ditches that appear in and near the contamination plume associated with MW-4.

1.3 Three revisions are necessary. One, match the constituents targeted by the CAP with the constituents of concern (COC's) listed in the ACM. Two sets of constituents characterizing groundwater contamination appear to exist. Six COC's are listed in the ACM; whereas, only three are listed in the CAP. Two, include lead and iron as additional COC's. Lead is reported in the ACM and CAP as "statistically significant" and detected above state groundwater standards. Iron is reported in the ACM and March 2008 Sampling Report as detected above background levels, consistently above the state groundwater standard, and, in MW-5 and MW-6, significantly higher than detections at surrounding wells. Three, explain how the contamination plume has been determined. In the ACM, no field data appears to have been used to delineate the plume. Unclear is how its dimensions are measured and how its migration will be monitored other than noting detections at MW-4.

1.4 Two revisions are necessary. One, expand the table to include lead, iron, and all the COC's listed in the ACM. Two, revise the "site conception model" to show the groundwater flow depicted on potentiometric maps submitted with the March 2008 Sampling Report. Flow based on the model utilized for the ACM show groundwater flowing in other directions.

2.1 Expand the list to include lead, iron, and all the COC's listed in the ACM.

2.5.2 Match the reported history of constituents exceeding groundwater standards with the history reported in the ACM. Numerous constituents detected above "2L" are mentioned in section 2.1.1 of the ACM that are not reflected in this section of the CAP.

4.1 Clarify whether it is MW-1 or MW-1R that will be utilized as the background well.

6.2 Include more data about the existing "passive horizontal gas venting system". Elaborate on how it has performed in the past as a "safeguard measure".

8.0 Two revisions are necessary. One, correct the statement to reflect that financial assurance for corrective action had not been submitted. Financial assurance had been shown for closure and post-closure but not for corrective action. Pursuant to Regulation 15A NCAC 13B .1628 (d) financial assurance for corrective action is also specified. Two, the cost estimate does not appear to reflect operation of the existing gas venting system mentioned in Section 6.2. More information about financial assurance is at the end of this letter.

Plates

Plate 3 Show location of the relevant point of compliance.

Ground and Surface Water Sampling and Analysis Plan

Include MW-5, MW-6, and MW-7 in assessment monitoring. The March 2008 Groundwater Sampling Report showed vinyl chloride detected in MW-5 and lead detected in MW-7, both at levels above the state groundwater standard. Iron has historically been detected in MW-5 and MW-6, both at levels above the state groundwater standard and background. Pursuant to Regulation 15A NCAC 13B .1634 (a) assessment monitoring is required when a violation of groundwater quality standard occurs.

The SWS received a letter from the chief financial officer of Greene County, dated March 27, 2009 regarding the financial assurance mechanism. Costs for closure and post-closure had been submitted but not for corrective action. Also, in Regulation 15A NCAC 13B .1628 (d)(1)(A) is the specification that the cost estimate be adjusted for inflation. Finally, not reflected in financial assurance for corrective action is cost of the gas ventilation system whose operation and maintenance is presumed to continue during the post-closure period. A revised financial assurance mechanism including a cost estimate for the CAP should be sent to Ms. Shawn McKee in the SWS. She can be contacted at 919-508-8512 or at: shawn.mckee@ncdenr.gov.

If you have questions, please contact me at 919-508-8401 or at: zinith.barbee@ncdenr.gov.

Sincerely,

Zinith Barbee

Zinith Barbee
Project Manager
Solid Waste Section

cc: Mark Poindexter	Field Operations Supervisor
Ed Mussler	Solid Waste Section
Pat Backus	SWS
Shawn McKee	SWS
Sean Patrick	Municipal Engineering Services Co., P.A.
Central File	

RECEIVED
MAY 1 4 2009
SOLID WASTE SECTION

Corrective Action Plan

Prepared for

Greene County Landfill - Permit #40-02
Walstonburg, Greene County, North Carolina

DRAFT

MESCO Project Number: G07061.0

Completed on 2/25/2009
Revised on 5/13/2009

Municipal Services Garner, NC
Engineering Company, P.A. Boone, NC

Municipal Engineering Services Company, P.A.
Garner, Boone and Morehead City, North Carolina

TABLE OF CONTENTS

DRAFT

TABLES

PLATES

APPENDIX

DRAFT

1 INTRODUCTION

1.1 Site Background

The Greene County Construction and Demolition (C&D) landfill is located at 105 Landfill Road (SR 1239), Walstonburg, Greene County, North Carolina. Greene County C&D landfill operates under permit #40-02. Prior to operating as a C&D landfill, the site operated as a Municipal Solid Waste (MSW) unlined sanitary landfill. The MSW unit was closed using an 18-inch cohesive soil cap with a permeability of 1×10^{-5} cm/sec, and 18 inches of erosive layer. The MSW unit stopped receiving waste by January 1, 1998 in accordance with the *Greene County Transition Plan* prepared for Greene County (the County) by Municipal Engineering Services Company, P.A April 1994.[6] The C&D landfill is constructed and operating on top of the MSW unit and, in accordance with Solid Waste Section (Section) Guidelines, is monitored under 15A NCAC 13B.1630. A topographic map presenting the location of the site is included as **Plate 1**.

1.2 Aquifer Characteristics

The site lies within the Coastal Plain physiographic province, which is characterized by flat or gently undulating topography and dissected by drainage features with narrow to moderately sloped sides. Topographic relief across the facility is approximately 20 feet. Surface drainage across the site is generally northeast towards a tributary of Sandy Run. Sandy Run flows east towards Little Contentnea Creek, which drains into the Neuse River. A site map showing the layout of the permitted facility is included as **Plate 2**.

The site is underlain by unconsolidated surficial deposits made up of sand, clay and gravel, which generally dip to the southeast. The surficial sediments are underlain by the Yorktown formation, which consists of an overlying confining unit of clay, silty clay, and/or sandy clay that is approximately 25 feet thick; followed by an underlying unit of fine sand, silty sand, and clayey sand.[4] Groundwater at the site is relatively shallow and typically occurs at depths of less than 20 feet below ground surface (bgs), with the shallowest depths occurring along the eastern side of the property. Groundwater static water level measurements in the monitoring wells have been generally consistent over time, and have been reported in the following depth ranges:

- ≤ 10 ft. bgs: *MW-1R, MW-6*
- 10 to 20 ft. bgs: *MW-4, MW-5, MW-7, MW-8*

DRAFT

Historical groundwater elevations are provided in **Table 2**. Local drainage features control primary groundwater flow dynamics. Groundwater located beneath the site appears to flow in an easterly direction away from the waste limits. A single-day potentiometric map depicting groundwater flow conditions recorded on March 28, 2008 is provided as **Plate 3**.

Hydraulic conductivity (K) values are summarized in **Table 3**. K values, as determined from slug testing performed by others in October 1994 [3] and by MESCO in June 2007 (after installation of monitor wells MW-7 and MW-8), reportedly ranged from 1.10 x 10^{-4} cm/sec (MW-4) to 1.14 x 10^{-3} cm/sec (MW-8), with a geometric mean of 2.07 x 10^{-4} cm/sec. Hydraulic gradient at the site was calculated to range from 0.015 to 0.025 ft/ft.

Average linear groundwater velocities (v_x) were calculated using the following equation:

$$v_x = \frac{K * i}{n_e}$$

where:

v_x represents the average linear velocity [length/time]

K represents the hydraulic conductivity [length/time]

n_e represents the effective porosity [unitless]

and

i represents the horizontal hydraulic gradient in the direction of groundwater flow, taken as the difference in head elevation between two points divided by the distance between those points [unitless, or length/length]

The calculated average linear velocities were found to have a median value of 33.4 ft/yr.

1.3 Contaminant Distribution

Groundwater contaminants of concern (COCs) at the site consisted of dissolved-phase volatile organic compounds (VOCs) and inorganic compounds (metals) in concentrations exceeding established 15A NCAC 2L Groundwater Standards (2L Standards). Five organic compounds, benzene, chloroethane, chloroethene (vinyl chloride), 1,4-dichlorobenzene (*p*-dichlorobenzene) and methylbenzene (toluene), were detected at levels above their respective 2L Standards. Inorganic constituents (metals) detected above their respective 2L Standards included cadmium, chromium, iron, lead, and manganese. Metals cadmium, chromium, iron, lead, vanadium, and zinc have also been detected in surface water samples.

As reported in the *Assessment of Corrective Measures* (*ACM*) prepared by MESCO in August 2007 [7] detection of the referenced metals in the background samples, surface water samples and soil samples suggest that they are probably naturally occurring and not directly attributed to the landfill waste stream. As a result, MESCO did not include the referenced inorganic analytes as COCs.

The contaminant plume was determined from plume models created by MODFLOW (with transport package $MT3D^{96}$) used to simulate a release. Modeling parameters assumed leakage occurred prior to installation of the CAP system. As with the development of the MODFLOW model, $MT3D^{96}$ Transport was calibrated during a trial and adjustment procedure. The retardation coefficient and dispersion factors were calibrated to time periods 2006 and 2007. In an attempt to incorporate historical data, MESCO used 1990 as a baseline, and target step periods of 5 years (1995), 16 years (2006), 17 years (2007), 25 years (2015), 35 years (2025), and 50 years (2040) were simulated in the model. The plume contour for 2007 was manually transposed from the simulations onto **Plate 5.** Based on plume contours, groundwater impact appeared to be limited to monitoring well MW-4 and, therefore, the unconfined surficial aquifer. To date, elevated levels of target analytes have not been detected in compliance wells MW-7 and MW-8. Historically detected organic constituents are presented on **Table 4**.

1.4 Site Conceptual Models

Site conceptual and analytical models were developed and presented in the *ACM*. The models consisted of conceptual cross sections and analytical modeling using MODFLOW with $MT3D^{96}$. The lithologic cross-sections presented in the *ACM* are provided as **Plate 4**.

Physical Process

The primary mechanism promoting physical movement of the plume is advection. Advection flow with applied sorption (retardation) coefficients (R) were calculated in the *ACM*. The following table expresses the anticipated time requirements for dissolved target analytes to reach the relevant point of compliance, excluding biological decay and dilution.

DRAFT

Contaminant Velocity (Presented in ACM)		
Monitoring Well	**MW-4**	**Time to relevant point of compliance (approx. 125 ft from MW-4)**
Benzene	3.46 ft/year	36.1 years
Chloroethane	6.29 ft/year	19.9years
Vinyl Chloride	12.6 ft/yrs	9.9 years
p-Dichlorobenzene	0.68 ft/year	183.8 year
Toluene	1.58 ft/year	79.1 years

The above table suggests that contamination has the potential to travel at or near the seepage velocities identified in the *ACM*. Summaries of the corrective action screening results as presented in the *ACM* are included as **Tables 8A-8E** (attached).

Chemical/Biochemical Process

Chemical degradation processes, primarily that of half-life decay, are typically presented in relation to surface water measurements [9]. However, there are no identified surface water receptors located within 2,000 feet of the landfill and the identified contamination consisted of constituents dissolved in groundwater. Benzene, chloroethane, and vinyl chloride experience rapid volatilization in soil when released near the surface and to surface waters. *p*-Dichlorobenzene and toluene volatilize rapidly when released into surface waters and experiences low to moderate adsorption when released into soils.[1] Half-life reactions in groundwater vary greatly. A summary of published half-life reactions in groundwater is included below.

Half-Life in Groundwater[2]		
Constituent	**Half-Life (high)**	**Half-Life (low)**
Benzene	24 months	10 days
Chloroethane	31 months	5.5 weeks
Vinyl chloride	70 months	14 weeks
p-Dichlorobenzene	12 months	8 weeks
Toluene	12 months	8 weeks

The identified COCs consisted of aromatic hydrocarbons and chlorinated aliphatic hydrocarbons dissolved in groundwater. Natural biodegradation of most chlorinated hydrocarbons, including halogenated aliphatics, occurs through reductive dechlorination.[2] Reductive dechlorination occurs as the result of microbial activity that progressively removes chlorine atoms from chlorinated hydrocarbons through various oxidation-reduction reactions. Under anaerobic conditions, reductive dechlorination occurs through electron acceptor reactions, with the chlorinated hydrocarbons acting as electron donors rather than as a carbon source for microbial activity. Under aerobic and some anaerobic conditions, reductive dechlorination can occur as a result of electron donor reactions, during which chlorinated hydrocarbons act as both carbon and energy sources for microbial activity [2].

1.5 Regulatory Status

The Greene County Landfill operates as a C&D landfill constructed over a MSWLF landfill under permit #40-02. Assessment monitoring is currently performed on a semi-annual basis at the site.

2 CONTAMINANT CHARACTERIZATION

2.1 Contaminants of Concern

The following chemical compounds were identified in the *ACM* as being contaminants of concern:

- benzene – *aromatic hydrocarbon*
- chloroethane – *chlorinated aliphatic* hydrocarbon
- vinyl chloride – *chlorinated aliphatic hydrocarbon*
- *p*-dichlorobenzene – *chlorinated aliphatic hydrocarbon*
- toluene – *aromatic hydrocarbon*

2.2 Contaminant Source Confirmation

The source of the release has been identified as the MSW landfill. The mechanism suspected for the presence of this contamination is precipitation that has percolated through the landfill waste, allowing VOCs to partition from solid/liquid phases into a dissolved phase, and that has subsequently migrated downwards to mix with groundwater. To limit water percolation, the MSW unit was closed with a 18-inch thick cohesive soil cap (permeability of 1×10^{-5} cm/sec) and 18 inches of erosive layer. Ultimately groundwater will discharge into unnamed creeks located east of the landfill. These creeks are tributaries of Sandy Run. There are no known groundwater users located within 2,000 feet of the facility.

2.3 Source Control Measures

The landfill stopped receiving MSW by October 1998 and was closed with an 18-inches thick cap of cohesive soil with a permeability of 1×10^{-5} cm/sec, and 18 inches of erosive layer. As indicated in Appendix III [Explosive Gas Control Plan for Greene County] of the *Transition Plan*, the County installed a passive horizontal gas venting system around the perimeter of the landfill in 1994. Permanent probes (sampling points) installed around the perimeter of the landfill were constructed of 1-inch slotted

DRAFT

Schedule 40 PVC pipe inserted into a 6-inch diameter augered hole to an approximate depth of six feet bgs. Probes were constructed with sufficient PVC riser to extend approximately three feet above the ground surface. The tops of the probes were capped with a PVC cap equipped with a ¼-inch NPT hose barb and 1-inch sample tubing. The bottom two feet of the borings were backfilled with pea gravel with an approximate one-foot thick cap of bentonite seal hydrated on top. The remaining annular space was backfilled with soil cuttings. Methane gas levels are monitored quarterly in the sampling points and landfill structures by County personnel using a combustible gas meter.

2.4 Risk Assessment

Risk assessment was performed as part of the *ACM* and assumed direct contact with the identified contamination. Exposure pathways are limited to on-site contact with groundwater. Monitoring wells are cased and secured with locking well caps. Access to the site is limited during operational hours. Adult hazard index values for the referenced COCs were "less than 1" from inhalation, dermal, and oral ingestion exposure. Additionally, child hazard index values for referenced COCs were less than 1 from inhalation, dermal, and oral ingestion exposure.

2.5 Contaminant Concentrations

2.5.1 Background Concentrations

Background water quality data is collected from upgradient monitoring well MW-1R. Water quality samples have been collected since 1994. Historical background results are shown in **Table 5**. Current groundwater results are shown in **Table 6**.

2.5.2 Exceedances of Groundwater Quality Standards

Groundwater contaminants that have exceeded 2L Standards include: benzene, cadmium, chloroethane, chromium, iron, lead, *p*-dichlorobenzene, vanadium, vinyl chloride, and toluene. Cadmium, chromium, and vanadium were found to be statistically insignificant. Lead and iron were reported in the *ACM* as occurring naturally and are not considered COCs in this study.

2.5.3 Exceedances of Surfacewater Quality Standards

Laboratory analysis of surfacewater samples have not detected contaminant concentrations in excess of established NCAC 2B surfacewater quality standards (2B Standards). Surface water samples are collected off-site at the tributary of Sandy Run. One (1) upstream sample and one (1) downstream sample are collected. Current surfacewater results are shown in **Table 7**. The upstream sampling point was dry during the March 2008 sampling event.

DRAFT

2.6 Media of Concern

Groundwater is the primary medium of concern at the site since it acts as the primary mechanism of transport for environmental contaminants emanating from the landfill. Dissolved-phase contaminants can potentially be transported via groundwater and discharged to surfacewater.

Landfill gas is a secondary medium of concern since it can transport VOCs that have partitioned into the vapor phase, allowing them to re-partition into the dissolved phase into groundwater.

3 SELECTED AND APPROVED REMEDY / TECHNICAL APPROACH

A number of factors influenced selection of remediation alternatives.

- Contamination has been detected within the relevant point of compliance.
- There are no potable wells or other receptors located within 2,000 feet of the facility.
- Contamination is below risk exposure levels.
- Contamination is limited to the unconfined, surficial aquifer.
- Natural attenuation mechanisms are actively controlling groundwater contaminant movement in this area.
- Modeling indicates that vinyl chloride will reach the relevant point of compliance in approximately 10 years. This does not include dilution, volatilization, dispersion, or degradation of contamination.

Remediation of relatively low level contamination in the 10 µg/L range can be difficult, expensive and may not be achievable. The most cost effective and efficient system for remediation is monitored natural attenuation (MNA) supplemented by phytoremediation.

3.1 Technical Approach (Monitored Natural Attenuation)

Bioscreen and *Biochlor* were initially run for MW-4 to assess the potential effectiveness of MNA. *Bioscreen* was focused on benzene due to the high half-life of two years. *Bioscreen* results presented a 47% decrease in contamination in five years through 1st-order decay and a 100% decrease in contamination through instantaneous reaction model. Results of *Bioscreen* are provided in **Appendix A.**

Biochlor utilized site specific data for cis-1,2-dichloroethene and vinyl chloride. Dual modeling was utilized based on high half-lives and low half-lives. High half-life results show an 8.1% decrease for cis-1,2-dichloroethene and a 5.5% decrease for vinyl chloride in 5 years through biotransformation modeling.

DRAFT

Low half-life results show a 51.4% decrease for cis-1,2-dichloroethene and a 48.5% decrease for vinyl chloride in 5 years through biotransformation modeling. Biochlor results are provided in **Appendix A**.

To more clearly delineate the extent of dissolved-phase VOCs in groundwater, it is recommended that additional groundwater samples be collected in the vicinity of monitoring well MW-4. To reduce costs, groundwater sampling may be conducted using direct-push methods (e.g. GeoProbe®). Baseline sampling of monitoring wells MW-1R and MW-4 will be performed semi-annually for a two-year period (four events), and will incorporate the MNA performance parameters listed in **Section 4** and **Appendix B**. Stream water quality monitoring will consist of sampling existing upstream and downstream surfacewater sampling points, located along the unnamed tributary of Sandy Run (see **Plate 2**).

4 GROUNDWATER AND SURFACEWATER MONITORING PLAN

4.1 Groundwater Sampling and Monitoring

Data with which to monitor and evaluate the performance of remediation shall be obtained through a groundwater sampling and monitoring program. All groundwater samples collected from the monitoring wells will be analyzed for Appendix I or Appendix II constituents in accordance with 15A NCAC 13B.1630. Additionally, groundwater samples collected from monitoring wells MW-1R and MW-4 will be analyzed for the following MNA performance parameters:

MNA Performance Parameters

Parameter	Analysis Type	Analytical Method
Dissolved Oxygen (DO)	Field Reading	Multi-parameter Field Instrument w/ flow-through cell
PH	Field Reading	
Oxidation-Reduction Potential (ORP)	Field Reading	
Turbidity	Field Reading	
Conductivity	Field Reading	
Temperature	Field Reading	
Dissolved CO_2	Field Reading	Field Instrument / Hach Kit
Alkalinity (Total as $CaCO_3$)*	Laboratory/Field*	EPA 310.2
Chloride*	Laboratory/Field*	SM 4500-CLB
Iron	Laboratory	SM3111B
Nitrate*	Laboratory/Field*	EPA 353.2 / SM 2320B
Sulfate*	Laboratory/Field*	EPA 375.4 / SM 4500-SO4E
Sulfide*	Laboratory/Field*	EPA 376.1 or SM 4500SE

DRAFT

MNA Performance Parameters		
Parameter	**Analysis Type**	**Analytical Method**
TOC/BOD/COD	Laboratory	EPA 415.1 / EPA 405.1 / EPA 410.1
Methane	Laboratory	RSK 175
Ethane, Ethene	Laboratory	RSK 175
Hydrogen	Laboratory	AM19GA
Volatile Fatty Acids	Laboratory	AM23G
*For budgetary considerations these analyses may be performed in the field using Hach® brand color wheel test kits.		

4.2 Surfacewater Sampling and Monitoring

Surfacewater sampling will be conducted to monitor COC concentrations in the adjacent stream areas. To date, COC concentrations have been detected below respective NCAC 2B Standards. Two (2) surfacewater sampling points designated "Upstream" and "Downstream" have been established along an unnamed tributary of Sandy Run. The locations of both surfacewater sampling points are depicted in **Appendix B, Plate A**. All surfacewater samples are analyzed for Appendix I VOC and metals concentrations by EPA methods 8260 and 6010, respectively. The complete *Groundwater and Surfacewater Sampling and Analysis Plan* is presented as **Appendix B**.

5 EVAULATION OF EFFECTIVENESS AND REPORT SUBMITTALS

5.1 Evaluation of Effectiveness

As remediation progresses at the site certain changes in the physical and chemical characteristics of the contaminant plumes should occur. In all areas contaminant concentrations are expected to decrease over the period of remediation, thus resulting in a decrease in the physical extent of the plume. The various methods for evaluating the effectiveness of remediation are discussed in the sections below.

5.1.1 Qualitative and Quantitative Evaluation

<u>*Qualitative Evaluation*</u>

Qualitative methods include graphical analysis of groundwater analytical data over time in order to visualize changing trends in groundwater chemistry that are expected to occur over time as a result of the various remedial mechanisms/processes that are occurring at the site (e.g. biodegradation, reductive dechlorination, etc.). Examples of graphical analyses that will be used include, but are not be limited to,

DRAFT

time-series graphs of contaminant concentrations and groundwater levels, distance-concentration graphs of analytical data, and mapping of the contaminant plumes over time.

Quantitative Evaluation

Quantitative evaluation will be conducted through annual revision of *Bioplume* and *Bioscreen* models, and through analysis of groundwater analytical data using statistical tests for significance. Statistical significance tests can be grouped into two types, *inter-well* and *intra-well*. *Inter-well* methods determine statistical significance by examining trends in contaminant concentrations from performance wells with respect to those from background wells, which are used as a control group. As remediation progresses, the performance well data is expected to exhibit decreases in contaminant concentrations, while contaminant concentrations in the background wells are expected to remain relatively stable. Background wells are selected on the basis of location (typically upgradient) and analytical history (non-impacted wells are best). *Intra-well* methods determine statistical significance within individual performance wells by examining historical analytical results (time series) for a given well, thus indicating if changing contaminant concentrations at a given well location result from either remedial activity or natural fluctuation. Comparisons of background well data with sentinel and compliance well data will also be performed to monitor groundwater contaminant movement over time.

Various types of significance tests have been developed to analyze differing types of data populations based upon characteristics such as distribution type (normal vs. non-normal), trend type (changing vs. non-changing), percentage of "non-detect" results for a given population, and the sample population size. This allows for the selection of particular methods that are appropriate for a given situation. For the remedial activity at the subject facility the following statistical tests are proposed for use, although others may be used as the course of remediation progresses:

- Wilcoxon Rank-Sum (Inter-well) - *normal or non-normal data, invariant trends, < 90% non-detects, >3 samples/per well.*
- Parametric Prediction Limit (Inter-well) – *normal data, varying trends,< 15% non-detects.*
- Parametric Prediction Limit (Intra-well) – *normal data, varying trends,≥ 4 samples/well, < 15% non-detects.*
- Non-Parametric Prediction Limit (Inter-Well & Intra-Well) – *normal or non-normal data, can tolerate high percentage of non-detects, compares recent to historical data.*

As indicated by the list above, it is important to note that, prior to conducting any test of statistical significance, a baseline of analytical data must first be established. For the MNA parameters listed in **Section 4.0** this baseline will consist of the four (4) semi-annual sampling events mentioned previously.

DRAFT

5.1.2 Evaluation of Plume Area

Monitoring well MW-1R will be used as the background well for inter-well statistical analysis of MNA data. Monitoring well MW-4 will be used as a performance well, while downgradient wells MW-5, MW-6, MW-7 and MW-8 will be used as compliance wells for assessment monitoring.

COC levels throughout the contaminant plume should decrease as a result of natural attenuation. Direct-push groundwater sampling may be necessary to collect additional groundwater samples around MW-4.

5.2 Refining the Site Conceptual Model

Over the course of corrective action the site conceptual model will be refined in order to determine the appropriate course of remediation. Additional information on groundwater chemistry, site lithology, plume characteristics, etc. will be used to further improve understanding of contaminant fate and transport at the site, and to determine any changes to the approved remedial measures if necessary.

5.3 Report Submittals

Corrective action sampling and monitoring reports will be submitted on a semi-annual basis, within 30 days of receiving all complete laboratory analytical reports. All reports submitted regarding evaluation of effectiveness will establish trends of the indicator parameters and contain tables, maps and figures relating to field and laboratory data. Laboratory reports, groundwater maps, contamination concentration maps and cross sections will be included. Specific parameters for individual plume areas will also be ascertained.

6 CONTINGENCY PLAN

6.1 Contingency Plan

Should the selected remedial approach not perform as expected and/or the constituent concentrations do not decrease within five years after implementation of remedial measures, contingency plans will be needed.

Phytoremediation

Should MNA fail to significantly reduce contaminant concentrations within two years of implementation, the process will be enhanced by the introduction of phytoremediation procedures. To accelerate the natural evapotranspiration process and to allow for hydraulic containment (plume control), the area surrounding MW-4, MW-5, MW-7, and MW-8 will be thinned of juvenile trees (those trees with a diameter of less than 3 inches) and pines, and planted with hybrid willows of the genus *Salix*. Hybrid

DRAFT

willows have been recognized as being "*phreatophytic*" (water-loving) trees with root systems that can extend up to 40 feet bgs. Phytoremediation is expected to occur through several processes: the release of enzymes from the root system that break down hydrocarbons (phytodegradation), limitation of infiltration by increasing evapotranspiration, and eventual uptake of hydrocarbons (phytoextraction). Available literature (e.g., Schnoor [8]) suggests an initial planting density of 1,000-2,000 trees/acre (~43 ft^2/tree). As the trees become established over time (1-2 years) competition between plants will reduce this density to ~600-800 trees/acre. The proposed phytoremediation area comprises approximately 1 acre; therefore, at the aforementioned planting density, a minimum of 1,200 hybrid willow seedlings will need to be planted at the onset of corrective action. Planting of seedlings will likely be performed by mechanical methods to reduce installation costs, and is tentatively scheduled to occur between August and September 2009. Protective fencing to prevent damage to the seedlings by wildlife (e.g. deer) is recommended around the area of planting. The proposed phytoremediation area is depicted in **Plate 5**.

Groundwater sampling will be performed semi-annually on monitoring wells MW-1R, MW-4, MW- 5, MW-6, MW-7, and MW-8. Baseline sampling for the suite of MNA performance parameters listed in **Section 4** and **Appendix B** shall be performed for two years following planting of hybrid willow trees. Soil sampling may also be conducted to monitor potential salt accumulation in the root zone. Phytoremediation sampling and monitoring results, in addition to information on tree growth and health, shall be included as a separate section within the semi-annual monitoring reports.

Alternate Substrates

Should MNA and phytoremediation fail to significantly reduce contaminant concentrations within three years of implementation, alternative substrates may need to be employed. Another substrate that has been shown to effectively reduce contaminant concentrations is oxygen-release compound (ORC). ORC, as manufactured by Regenesis, Ltd., consists of a dry mixture of calcium hydroxides with potassium phosphates that, when mixed with water, is injected into the subgrade as a slurry. Issues to consider prior to its use are its high pH (11-13), and its insolubility, that may lead to settlement during mixing and handling. Hydrogen release compound (HRC) has been shown to effectively enhance reductive dechlorination of halogenated hydrocarbons, but to be less effective with remediating aromatic hydrocarbons. The design and implementation of alternate injection substrates is beyond the scope of this CAP report.

DRAFT

6.2 Safeguard Measures and Site Security

Exposure pathways are limited to on-site contact with groundwater. Monitoring wells are cased and secured with locking well caps. Access to the site is limited during operational hours. Public water is available to the surrounding area. As discussed earlier in Section 2.3 Source Control Measures, a passive horizontal gas venting system for methane extraction/collection was installed as part of the *Transition Plan.* [6]

6.3 Revisions

Requests for modification of the approved corrective action and implementation schedule will be submitted in writing to the Solid Waste Section. No actions regarding modification will be implemented until written approval is received from the Division of Waste Management.

7 SCHEDULE AND MAINTENANCE

7.1 Operations and Maintenance

Greene County will oversee day-to-day operation and upkeep of the remediation technology. Any equipment required for remediation will be the responsibility of the County. If problems with the remediation system arise, the Solid Waste Section will be notified and a written report will be issued. The Greene County Department of Solid Waste can be contacted at (252) 747-5720 regarding daily activities.

7.2 Timeline

Implementation of corrective action will begin within 30 days of CAP approval. Initial activities will consist primarily of administrative tasks including scheduling of drilling and remediation sub-contractors, permit preparation/submittal, and materials purchasing. A timeline estimate for sampling events and performance evaluation is presented in **Table 9**.

8 FINANCIAL ASSURANCE REQUIREMENTS

In general accordance with 15A NCAC 13B .0546, demonstration of financial assurance was achieved through the local government financial test. Semi-annual sampling costs are/were estimated in the post closure financial assurance. However, even though estimated costs to perform corrective action and an initial contingency plan (phytoremediation) are relatively minor, to date, financial assurance for corrective

DRAFT

action has not been submitted. MNA sampling is incorporated with the semi-annual sampling. The additional expense for MNA is seen in laboratory costs.

GeoProbe Groundwater Sampling Subcontractor Services..$2,500
MNA Samples (4 @ $750/sample)...$3,000
Estimated Total Cost..$5,500

The estimated additional expense to clear and grub the recommended area around MW-4, MW-5, MW-7, and MW-8, and purchase and plant approximately 1,000 willow trees is:

Phytoremediation... $5,000

9 COMPLETENESS OF CORRECTIVE ACTION

Results indicate that reduction of the low level contamination can be achieved through monitored natural attenuation supplemented with phytoremediation. There is no indication that the contamination will reach the relevant point of compliance in a reasonable time period. Institutional controls limit access to the site. Public water is available to the surrounding area. The source area has been capped to limit the infiltration. Monitored Natural Attenuation will be implemented to correspond with semi-annual sampling.

Respectfully submitted
MUNICIPAL ENGINEERING SERVICES COMPANY, P.A.

DRAFT

Sean K. Patrick, P.G.
Professional Geologist

DRAFT

Stephen Mark Brown, LG, PG
Senior Geologist

DRAFT

REFERENCES

[1] EPA Technical Factsheets, http://www.epa.gov/OGWDW/contaminants/index.html

[2] Environmental Protection Agency (EPA), 1998, Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in the Ground Water, EPA/600/R-98/128, September.

[3] GAI Consultants, 1994, Water Quality Monitoring System Modifications and Water Sampling and Testing, Greene County Landfill, Wootens Crossroads, North Carolina, Permit No. 40-02.

[4] Giese, G. L., Eimers, J. L., Coble, R. W., 1997, Simulation of Ground-Water flow in the Coastal Plain Aquifer System of North Carolina. U.S Geological Survey Professional Paper 1404-M, 142p.

[5] Howard, P.H., Boethling, R.S., Jarvis, W.F., Myelan, W.M., and Michalenko, E.M., 1991, Handbook of Environmental Degradation Rates, Lewis Publishers, Inc, Chelsea, MI.

[6] Municipal Engineering Services Company, P.A, April 1994. *Greene County Transition Plan.*

[7] Municipal Engineering Services Company, P.A, August 2007. *Assessment of Corrective Measures*, Greene County Landfill – Permit #40-02

[8] Schnoor, J.L., October 1997, *Phytoremediation*, The University of Iowa, Department of Civil and Environmental Engineering, Groundwater Remediation Technologies Analysis Center.

[9] US Department of Health and Human Services, Agency for Toxic Substances and Disease Registry, 4770 Buford Highway NE, Atlanta, GA 30341, http://www.atsdr.cdc.gov

DRAFT